

Update on signal simulation in WireCell

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Noise simulation

- Noise in frequency domain (fit to MicroBooNE data)
- Gain = 14 mV/fC
- Shaping time = 2 μ s
- Noise baseline is calculated as an averaged r.m.s.
- Noise r.m.s. is scaled by

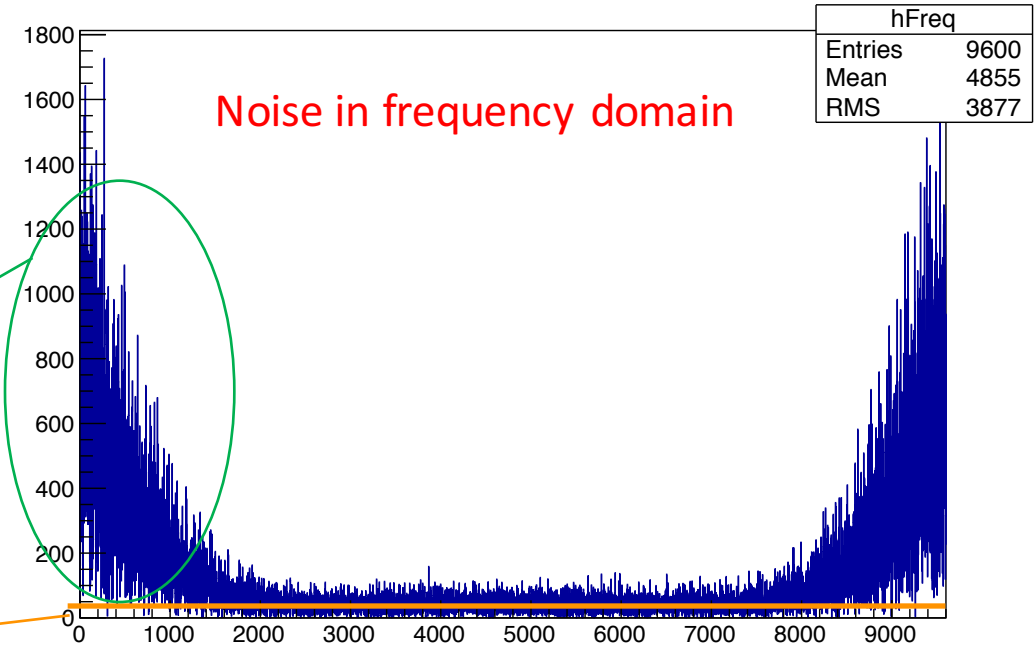
$$\frac{r.m.s.}{baseline} \times (1.020 + 0.0018 \times L(cm))$$

Fit to MicroBooNE data

Digitization noise

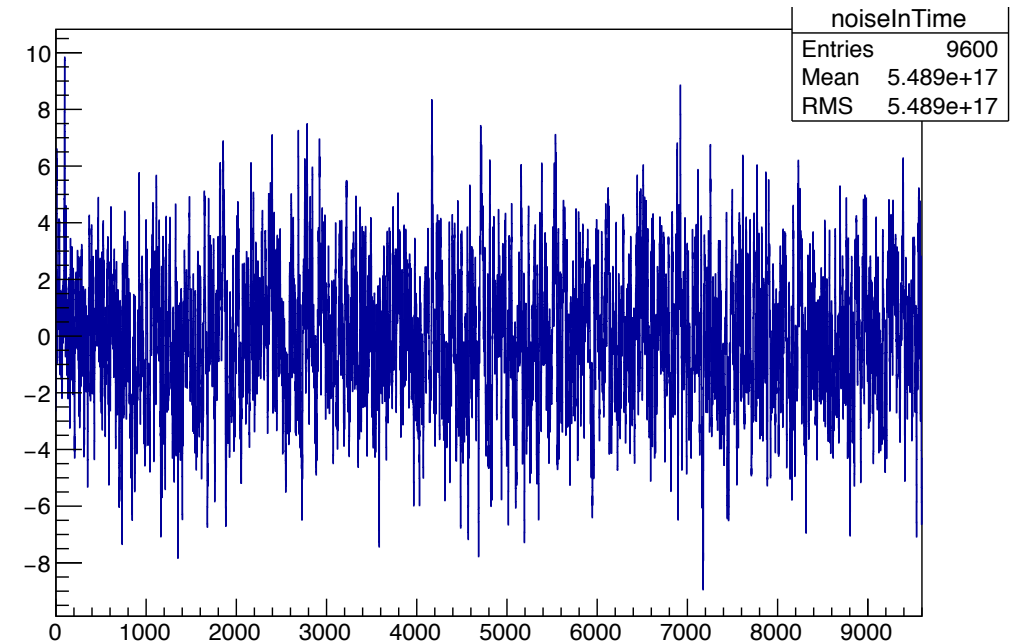
Other noises

Noise in frequency domain



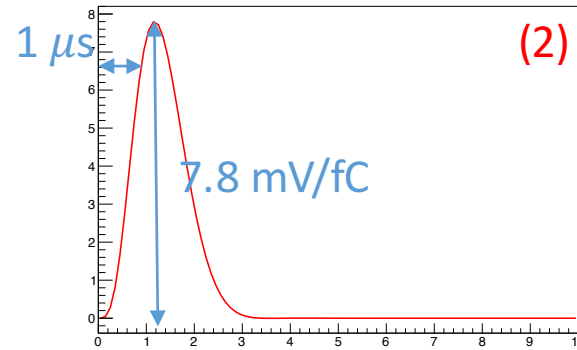
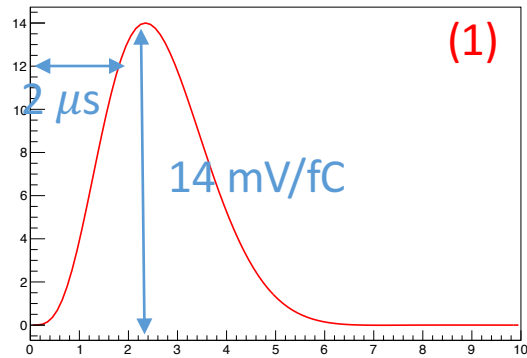
Noise in time domain

r.m.s. = 2.4

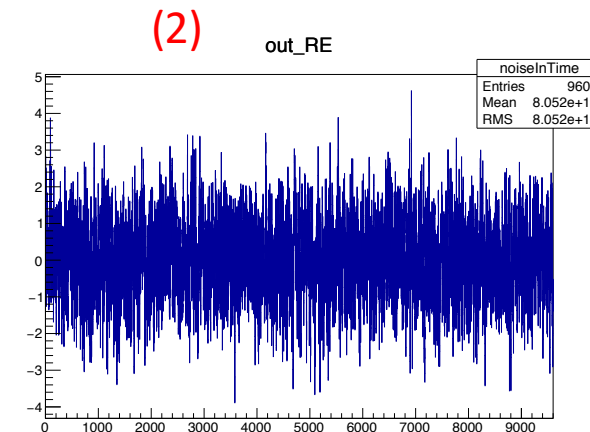
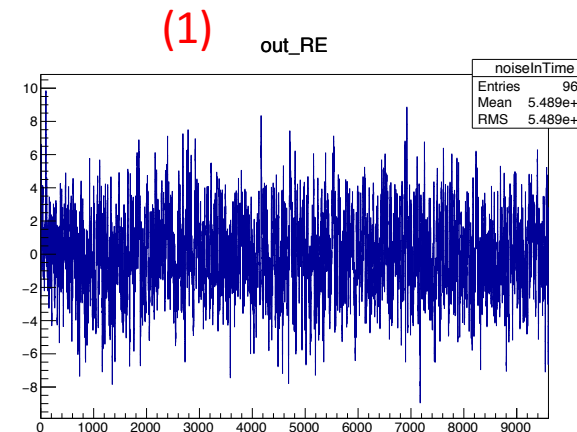
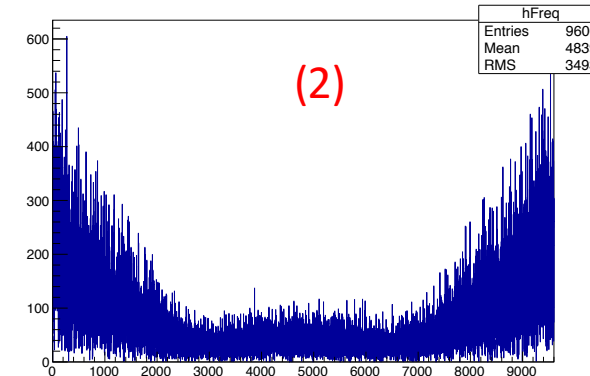
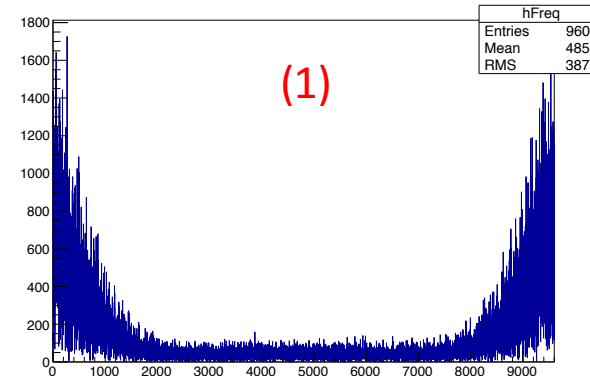


Noise simulation

- Parameterized electronics response

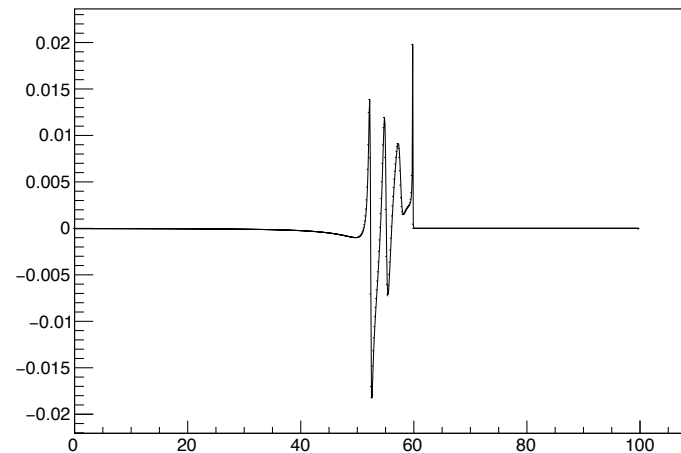
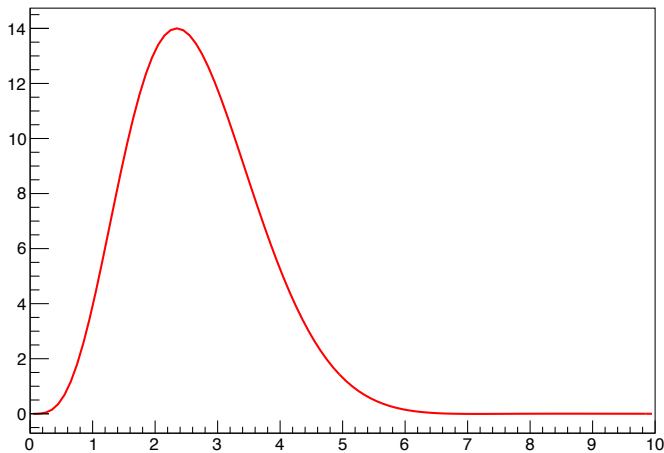


- In the case of different gain and shaping time configuration:
 - Digitization noise is independent of electronics configuration.
 - All other noise components can be scaled by electronics response function in frequency domain.

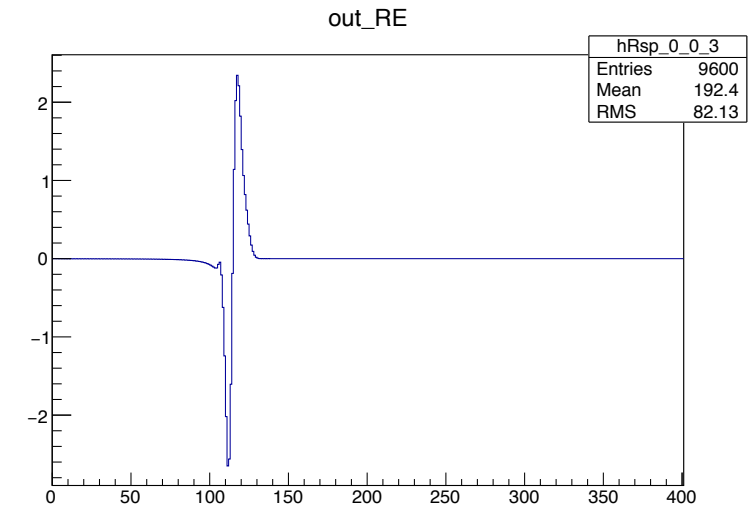


Signal simulation

- In order to speed up, first calculate the convolution of electronics response function and field response functions.

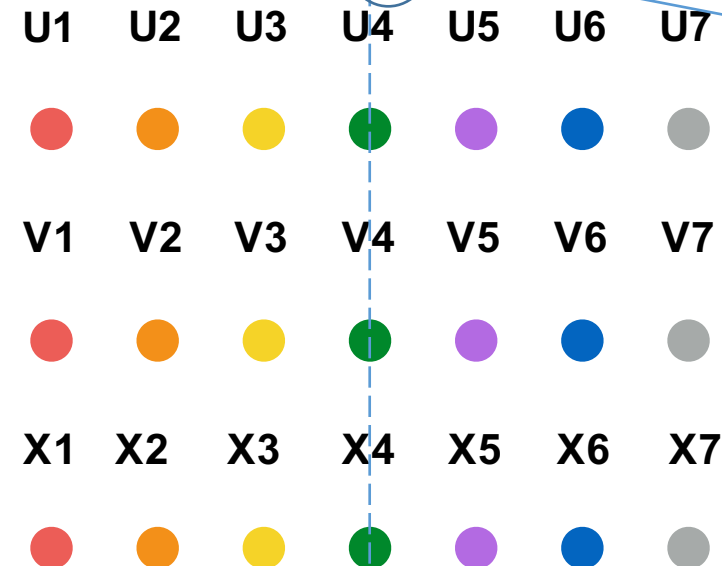
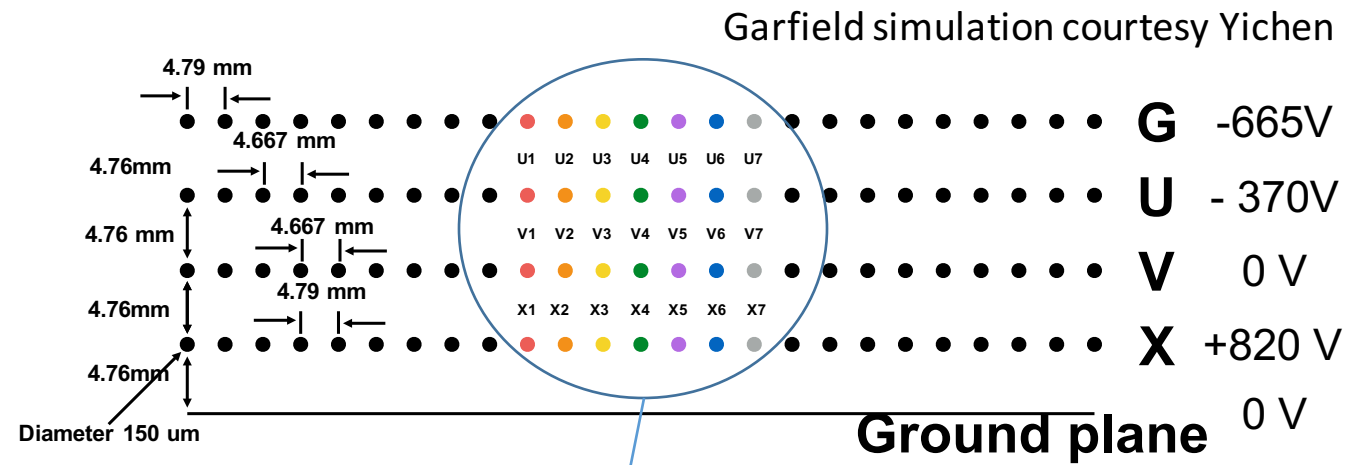


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Signal simulation

- Averaged field response function was used in the previous signal simulation, in which case effect of different impact parameter is ignored. Moreover, a charge deposition is only to induce current on the nearest wire.
- In the new simulation, more detailed field response functions are used, and a charge deposition is allowed to cause induced current in adjacent wires.

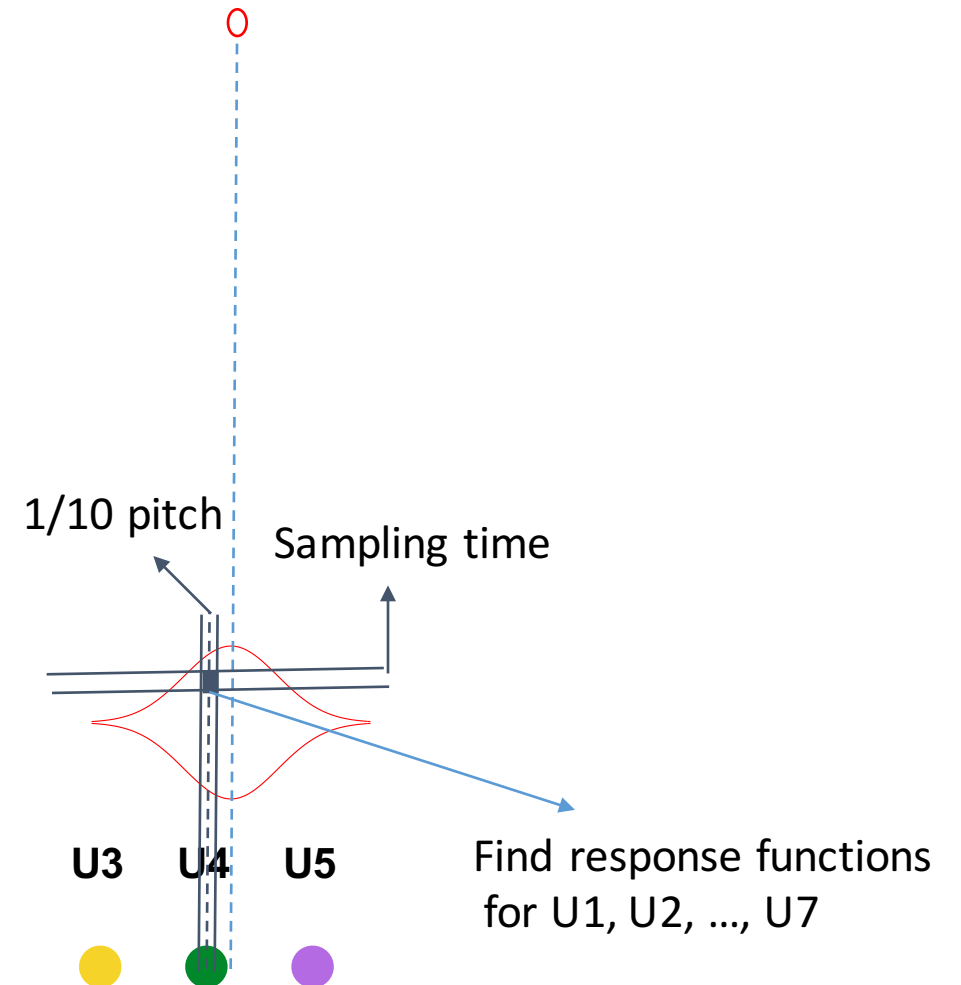


Distances from dotted line:
0 mm, 0.479 mm,
0.958 mm, 1.437mm,
1.916mm, 2.395mm.

Each of the seven wires has its own field response functions corresponding to all six impact positions.

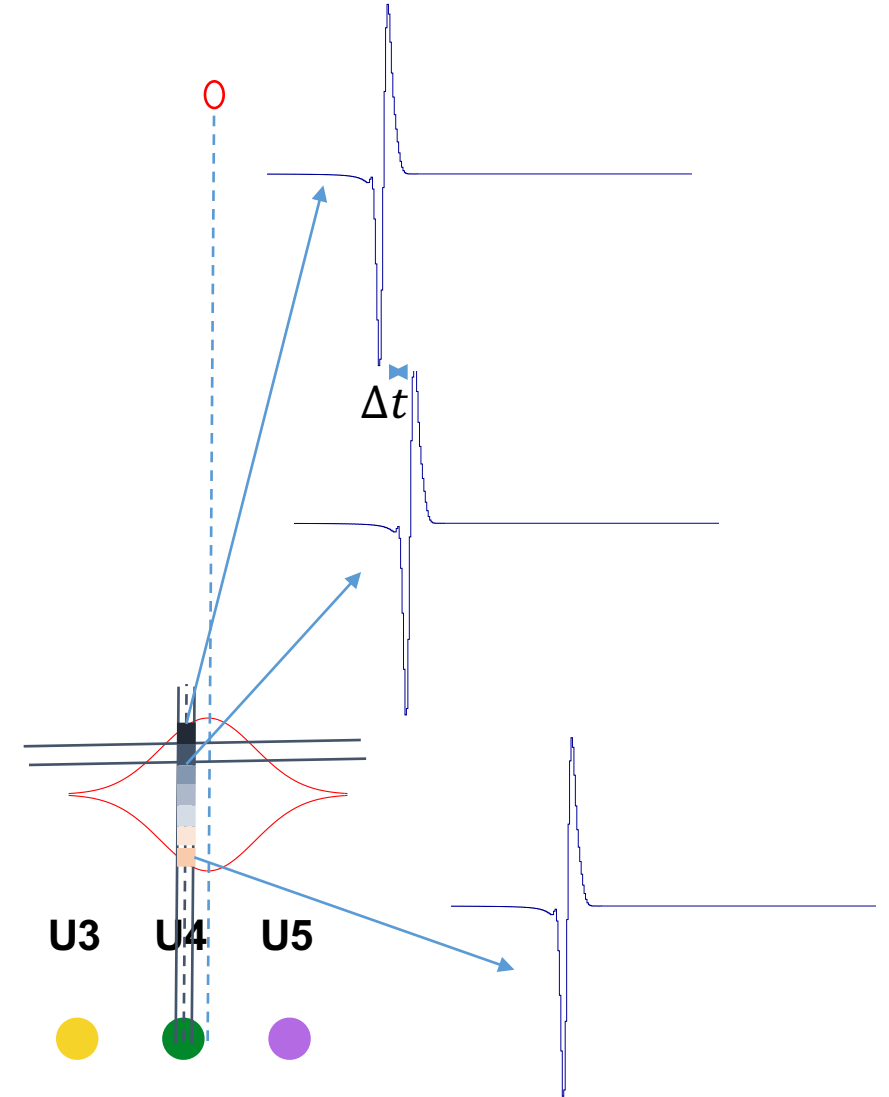
Signal simulation

- Diffusion is dependent on drift time at given E-field.
- In the simulation, a charge deposition is developed into a 3D Gaussian “cloud” trimmed at $\pm 3\sigma$. Total amount of charge is unchanged.
- Slice this “cloud” in both longitudinal direction and transverse direction with respect to a certain wire plane.
- For each grid, determine which response functions to use.



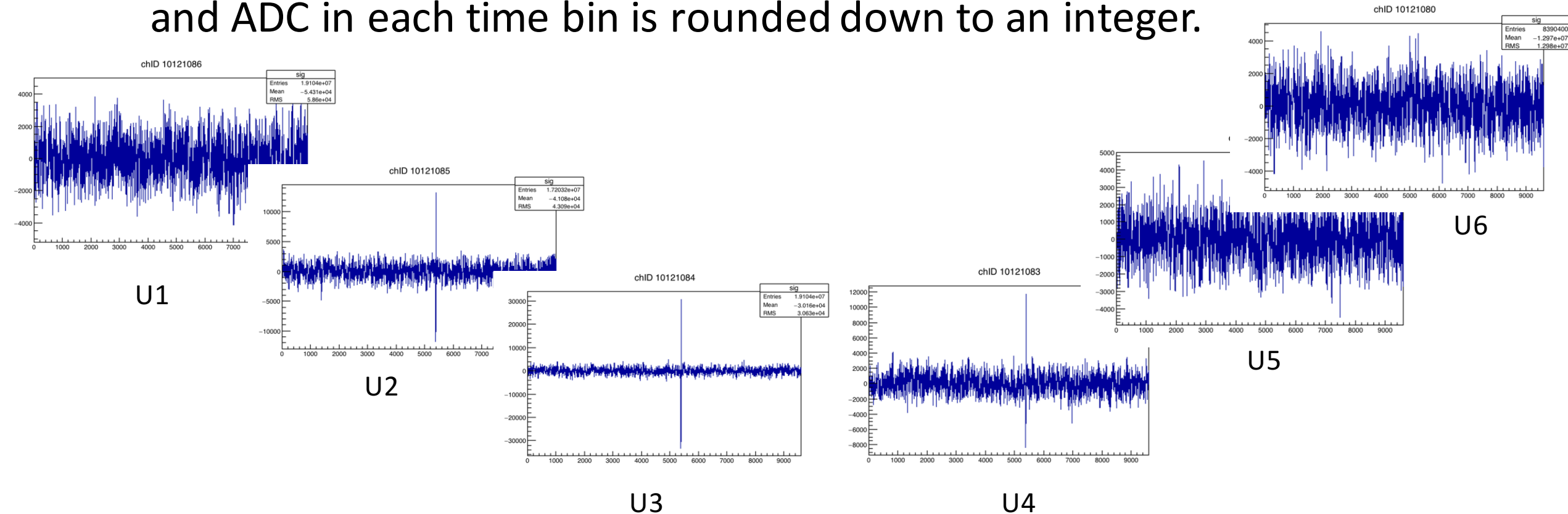
Signal simulation

- Consider U4 only.
 - Each charge grid can be considered a delta function. Its convolution with response function amounts to the response function itself with a time shift corresponding to the TDC of the grid.
 - Add all contributions from different time slices.
 - Add all contributions from different spatial slices.
 - Add all contributions from different charge depositions.



Signal simulation

- In the end, a pink noise waveform is added to the raw signal waveform, and ADC in each time bin is rounded down to an integer.



Progress and outstanding issues

- Speed is the main issue.
 - Previously have been having memory problems. They have been resolved but it did not speed it up (still ~ 0.5 sec per charge deposition). It is possible that this method is intrinsically time-consuming.
 - Finding alternative ways of bettering signal simulation.
- Visualization programs, previously developed for MicroBooNE data, need to be adapted to work on simulation as well as DUNE/protoDUNE geometry.